Biochemistry

Molarity, Molality, and Normality

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2K21/MLT/09

Mass Percent

- ✓ Solutions can also be represented as percent of solute in a specific mass of solution.
- ✓ For a solid dissolved in water, you use percent by mass which is Mass Percent.
- ✓ $\% \text{ by mass} = \dfrac{\text{mass solute} \times 100}{\text{mass of solution}}$
- ✓ **Mass of solution = solute mass + solvent mass

<u>Example 1</u>

- If a **solution** that has a mass of 800.0 grams contains 20.0 grams of NaCl, what is the concentration using **Percent by Mass**?

$$\% \text{ by mass} = \frac{\text{mass solute} \times 100}{\text{mass of solution}}$$

$$\% \text{ by mass} = \frac{20.0\text{g NaCl} \times 100}{800.0\text{g solution}}$$

$$= 2.50\% \text{ NaCl}$$

Normality example #2: What is N of 20.0g NaOH dissolved in 1.0 L of solution ?

$$20.0\text{g NaOH} \times \frac{1 \text{ equiv. NaOH}}{40.0\text{g}} = 0.5 \text{ equiv.}$$

$$N = \frac{\text{\# of equivalents}}{\text{Liter of solution}} = \frac{0.5 \text{ equiv.}}{1 \text{ L}} = 0.5 \text{ N}$$

Normality example #3: What is N of 4.90g H_2SO_4 dissolved in 500 mL of solution ?

$$4.90\text{g } H_2SO_4 \times \frac{1 \text{ equiv. } H_2SO_4}{49.0\text{g}} = 0.10 \text{ equiv.}$$

$$N = \frac{\text{\# of equivalents}}{\text{Liter of solution}} = \frac{0.10 \text{ equiv.}}{0.5 \text{ L}} = 0.2 \text{ N}$$

Dilutions with Normality:

What if you wished to dilute a more concentrated Normal solution to a specific concentration. How would you do it ?

$$N_iV_i = N_fV_f$$

Normal Dilutions example #1:

A lab requires 500 mL of 0.20 N Sulfuric acid. You have a significant volume of 4.0 N H_2SO_4.

How do you prepare the desired solution ?

$N_iV_i = N_fV_f$ $\quad$ 0.20 N x 0.500 L = 4.0 N x "X"

"X" = 0.025 L

Dilute 25 mL of 4.0 N Sulfuric acid to 500 mL.

Normal Dilutions example #2:

A lab requires 870 mL of 2.0 N Potassium hydroxide. You have a significant volume of 3.0 N KOH.

How do you prepare the desired solution ?

$N_iV_i = N_fV_f$

2.0 N x 0.870 L = 3.0 N x "X"

"X" = 0.58 L

Dilute 580 mL of 3.0 N Potassium hydroxide to 870 mL.

Example 2

If 10.0 grams of NaCl is dissolved in 90.0 grams of **water**, what is the concentration using **Percent by Mass**?

$$\% \text{ by mass} = \frac{\text{mass solute} \quad \times 100}{\text{mass of solution}} \qquad \% \text{ by mass} = \frac{10.0\text{g NaCl}}{100.0\text{g solution}} \times 100 = 10$$

Example 3

How many grams of sodium bromide are in 200.0g of solution that is 15.0% sodium bromide by mass?

$$\% \text{ by mass} = \frac{\text{mass solute} \quad \times 100}{\text{mass of solution}}$$

$$\% \text{ by mass} = \frac{?\ \text{gNaBr}}{200.0\text{g solution}} \times 100 = 15.0\%\text{NaBr}$$

$$\text{g NaBr} = \frac{200.0 \times 15.0}{100} = 30 \text{ g NaBr}$$

Molality

The number of moles of solute per kilogram of solvent.

Molality example #1: 5.67g of glucose are dissolved in 25.2g of water.

What is the Molality ?

Step #1: Determine the number of moles of solute.

Molecular weight of glucose = 180.1572 g/mol

Use "DIMO" to determine # of moles.

$$\frac{5.67\text{g}}{180.1572 \text{ g/mol}} = 0.0315 \text{ mol of glucose}$$

Step #2: Determine the mass of the solvent.

Given 25.2g = 0.0252 Kg"X"

Step #3: Set up proportions to solve.

$$\frac{0.0315 \text{ mol glucose}}{0.0252 \text{ Kg solvent}} =$$

X = 1.25m glucose

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X = 1.25m glucose

Molality example #3:

Fructose, $C_6H_{12}O_6$, is a sugar found in honey and fruits. The sweetest sugar, it is nearly twice as sweet as sucrose.

How much water should be added to 1.75g of fructose to give a 0.125m solution of Fructose ?

Step #1: Determine the number of moles of solute.

Molecular weight of Fructose = 180.1572 g/mol

Use "DIMO" to determine # of moles.

$$\frac{1.75\text{g}}{180.1572\text{ g/mol}} = 0.00971\text{ mol of Fructose}$$

Step #2: Determine the mass of the solvent.

Given "X"g = Kg "X"

Step #3: Set up proportions to solve.

$$\frac{0.125\text{ mol Fructose}}{1\text{ Kg solvent}} = \frac{0.00971\text{ mol Fructose}}{\text{"X" Kg solvent}} \qquad X = 0.07768\text{ Kg of solvent}$$

Which equals solvent. "X" 77 . 68g

Step #4: Use the density of water to convert grams to milliliters.

Molar Solutions –Dry Chemicals

✓Mole Mass Conversion

✓**Grams/L x (1/MW) = Moles/L**

Example:

Need to know how many grams of NaOH to make 1Litre of 2M.

Rearrange equation: to show that the grams is the unknown we what to find.

✓Grams= Moles / (1/MW)

✓Grams =2M / (1/40.01)

✓Grams= 80.02 of NaOH /Litre of distilled water.

✓**Caution this is exothermic reaction.**

Figure 21.4. A 1 M Solution of Sodium Sulfate (Na_2SO_4). The FW of Na_2SO_4 is

Molar Solutions- Wet Chemicals

Important to remember check the label you need to know the starting strength (%)

Grams = Density x 1000ml x %

Example: HCl comes in two different strengths 32% and 36%.

Grams = 1.179g/ml x1000ml x 36%

Grams = 1.179g x1000 x0.36

Grams = 424.44

Molar Solutions- Wet Chemicals

Next step to work out the number of moles.

Grams x (1/MW) = Moles

Rearrange to find the number Moles.

M= (g x 1000ml) / (MW x ml)

M= (424.44g x 1000) /(36.46 /1000)

Moles = 11.64M

This is the strength of your HCl

Now work out how many Moles is 32% HCl.

Next Step is dilution.

Example : 32% HCl = 10.17 M and you need to make 500mls of 2M.

$$M1 \times V1 = M2 \times V2$$

M1=The original number of moles of HCl 10.17

V1= How much do we need?

M2 = Moles needed 2M

V2 = Volume needed 500mls

$$10.17M \times V1ml = 2M \times 500ml$$

Rearrange to find V1

$$V1 = (2 \times 500)/10.17$$

$$V1 = 98.33ml$$

✓Sulphuric acid. 96-98%

1. Grams = Density x 1000ml x %
2. M= (g x 1000ml) / (MW x ml)

Step1.

Grams= 1.84g/mlx 1000mlx 96%

Grams=1.84g x 1000ml x0.98

Grams=1803.2

Step 2.

M= (1803.2 x1000ml) / (96.07x/1000ml)

M= 18.85

Then dilute to suit the moles you require.

- ✓ When mixing solutes what is the final Mole?
- ✓ Example: 50ml of 0.5M NaOH with 250ml of 1M NaOH What is the final molar strength.

M1V1+M2V2= M3V3

M1= 0.5M ; V1 = 50ml; M2 = 1.0; V2 =250ml

M3 = unknown; V3 = 300ml

Rearrange to find M3

M3= (0.5Mx50ml+1.0M x 250ml) /300

M3=0.92M

Always Check.

✓**Does the Chemical have water added?**

This needs to be taken into consideration when considering the Molecular Weight (MW).

✓**Read the information on the Chemical container label.**

Example. Copper Sulphate comes in Anhydrous $CuSO_4$(pale green to white powder) and Pentahydrate. $CuSO_4.5H_2O$ (bright blue powder)

$CuSO_4$ =159.62g/mol $CuSO_4.\ 5H_2O$ = 249.70g/mol

This will affect your accuracy of your chemical solution.

Liquids chemicals always check the % and density

What if I don't want a litre of solution?

$NaOH$ example: 80.02g/L to make 2M

You only need 250mls.

$$1000/250 = 4$$

$$80.02/4 = 20.005g$$

Therefore you need 20.005g of $NaOH$ to make up 250mls.

Concentration Expressions (Most Common)

PARTS (Common in environmental sciences, for example)

Amounts of solutes expressed as "parts"

a. Parts per Million (ppm)

b. Parts per Billion (ppb)

c. Might see parts per Thousand (ppt)

d. Percents are same category (pph %)

Parts may have any units but must be the same for all components of the mixture.

Example:

A solution is 3:2:1 ethylene:chloroform:isoamyl alcohol

Might combine:

3 liters ethylene

2 liters chloroform

1 liter isoamyl alcohol

Two Other Forms Of %

v/v $\frac{\text{mL solute}}{\text{100 mL solution}}$

w/w $\frac{\text{g solute}}{\text{100 g solution}}$

Weight/weight

How would you make 500 g of a 5% solution of NaCl by weight (w/w)?

Percent strength is 5% w/w, total weight desired is 500g.

5% = 5g/100g

$\frac{0.05g}{}$ X 500 g = 25 g = NaCl needed

500 g − 25 g = 475 g = amount of solvent needed

Dissolve 25 g of NaCl in 475 g of water.

Weight / Volume

Means a fraction with:

$$\frac{\text{weight of solute in numerator}}{\text{total volume in denominator}}$$

2 mg/mL proteinase K

Means 2 mg of proteinase K in each mL of solution.

Example: How much proteinase K is required to make 50 mL of solution at a concentration of 2 mg/mL?

Can Solve as A Proportion Problem

$$\frac{\text{2 mg proteinase K}}{\text{1 mL solution}} = \frac{X}{\text{50 mL solution}}$$

X = 100 mg

= amount proteinase K needed.

Volume / Volume

Means a fraction with:

$$\frac{\text{volume of solute in numerator}}{\text{total volume in denominator}}$$

Usually the "solute" here is a liquid as well

Remember that volume in the denominator is the total volume of the solution

Example

- ✓ You are to make 50 mL of a 8% v/v solution of diluted dish soap.
- ✓ How many mLs of concentrated dish soap must be added to how many mLs of water?
- ✓ Weight / Weight
- ✓ Means a fraction with:

$$\frac{\text{mass of solute in numerator}}{\text{total mass in denominator}}$$

- ✓ Most times the "solute" here is a solid and sometimes the "solution" is also a solid
- ✓ **<u>Remember that mass in the denominator is the total mass of the solution</u>**

- ✓ Example:
- ✓ You are to prepare 4 kg of specific soil sample which is to be 8% w/w sand and 5% w/w clay in which the remainder is top soil.
- ✓ How many grams of each sand and clay need to be added to the soil to make the solution?

Ppm And Ppb

- ✓ **ppm:** The number of parts of solute per 1 million parts of total solution.
- ✓ **ppb:** The number of parts of solute per billion parts of solution.

Ppm Example

5 ppm chlorine = 5 g of chlorine in 1 million g of solution,
or 5 mg chlorine in 1 million mg of solution,
or 5 pounds of chlorine in 1 million pounds of solution

Conversions

To convert ppm or ppb to simple weight per volume expressions:
5 ppm chlorine

To convert ppm or ppb to simple weight per volume expressions:

5 ppm chlorine = $\frac{5\text{ g chlorine}}{10^6\text{ g water}} = \frac{5\text{ g chlorine}}{10^6\text{ mL water}}$

= **5 mg/1 L water**

= 5×10^{-6} g chlorine/ 1 mL water

= **5 micrograms/mL**

PPM To Micrograms/ml

For any solute:

1 ppm in water = $\frac{\text{1 microgram}}{\text{mL}}$

Each star represents 1 mg of dioxin. What is the concentration of dioxin in the beaker expressed as ppm (parts per million)? ____________ What is the total amount of dioxin in beaker?

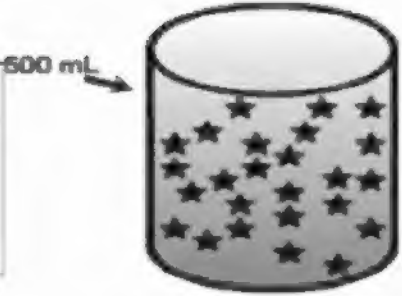

Figure 5

Each star represents 1 mg of dioxin. What is the total amount of dioxin in tube? <u>25 mg</u> What is the concentration of dioxin in tube expressed as ppm? ____________ *1 ppm in water =* $\frac{1\ \mu g}{mL}$ 25 mg/500 mL = 0.05 mg/mL= 50 µg/mL so the concentration is 50 ppm

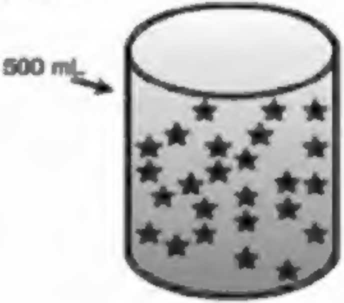

Figure 5